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Transit Temperatures of California Iceberg Lettuce Shipped by Truck During the Hot Summer Months

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Abstract

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This report describes the results of 10 test shipments of naked-pack iceberg lettuce shipped by highway trailer during the warm summer months. On arrival at eastern markets, lettuce in boxes that were loaded directly on the floor averaged 4.6°F (2.6°C) warmer than lettuce in boxes that were loaded on racks that raised the lettuce about 4 inches (10.1 cm) above the truck floor. The temperature of lettuce loaded against trailer sidewalls that had recessed vertical grooves was about 2°F (1.1°C) cooler than the temperature of lettuce loaded against sidewalls that were flat.

This study also included an enumeration of the various features of 623 randomly selected trailers at lettuce loading docks in central California in 1979. Most had flat sidewalls, wide canvas air-delivery chutes, front bulkheads, and extruded aluminum grooved floors. Most of the trailers were not precooled before loading.

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TRANSIT TEMPERATURES OF CALIFORNIA ICEBERG LETTUCE SHIPPED BY TRUCK DURING THE HOT SUMMER MONTHS

By R. Tom Hinsch, Roger E. Rij, and Robert F. Kasmire[1]

Introduction

Shipments of western iceberg lettuce constitute the largest volume of any single perishable item shipped out of California and represent 27 percent of all carlots of fresh fruits and vegetables shipped out of State (*6*).[2] More than 90 percent of this lettuce was shipped by highway truck in 1978, and almost 40 percent was shipped during the hot summer months of June through September (*7*).

Many refrigerated, piggyback trailers that travel on railroad flatcars have arrived at their destination with lettuce temperatures of 40°F (4.5°C) or higher (*5*). A van container designed for overseas shipments with the USDA reverse airflow circulation system has proven itself capable of maintaining desirable transit temperatures for lettuce (*2*); however, highway trailers with this type of refrigeration system are not presently available for domestic transport.

In their study on maintaining uniform cargo temperatures in loads of respiring produce, Sharp and Irving (*4*) concluded that a minimum depth of 5 cm (2 inches) is required between the truck floor and the load to avoid restriction of the airflow for fruit packed in fiberboard cartons. Temperature variations within the load would be reduced, and a more constant temperature could be achieved if air could get around the periphery of the load.

In 1979, the California iceberg lettuce industry expressed concern for the large number of high-temperature arrivals that they experienced in highway trailers during the warm summer months. Most lettuce is loaded directly on the shallow ribbed floors of refrigerated trucks. This study was conducted to determine the locations where high arrival temperatures occurred in commercial lettuce loads and to determine if raising the load off the floor would result in more desirable temperatures. During this study, we also conducted a survey of the type of truck trailer equipment used to carry California lettuce to distant markets.

Procedure

Ten test shipments of iceberg lettuce in truck trailers were made from Salinas, Calif., to southern and eastern marketing areas during the hot summer months. We studied two types of loads (1) naked-pack lettuce, hand or machine loaded directly onto the highway trailer floor; and (2) naked-pack lettuce that was machine loaded and stacked on wooden racks that raised the lettuce off the highway trailer floor. Naked lettuce is lettuce that has been packed directly into the shipping container without any additional packaging materials around individual heads.

The wooden racks (fig. 1) that were used in some of the naked lettuce loads raised the load about 4 inches (10.1 cm) above the trailer floor to allow more refrigerated air to circulate under the load, much as it would in palletized loads. At present, naked lettuce is not commercially palletized, so the floor racks were designed to serve this function.

We did not pick the specific type of refrigerated trailer equipment to be used in these tests, but randomly accepted trailers that represented the type of equipment presently used by the lettuce industry. We placed recording thermometers at 11 locations in each load (fig. 2), in the discharge airstream from the refrigeration unit, and in the return airstream. An addi-

Figure 1.—Wood floor racks used to raise naked-pack lettuce off the floor of refrigerated trailers.

[1]Hinsch and Rij are agricultural marketing specialists, USDA-SEA, Fresno, Calif.; Kasmire is an extension specialist, University of California, Davis.
[2]Italic numbers in parentheses refer to Literature Cited, p. 5.

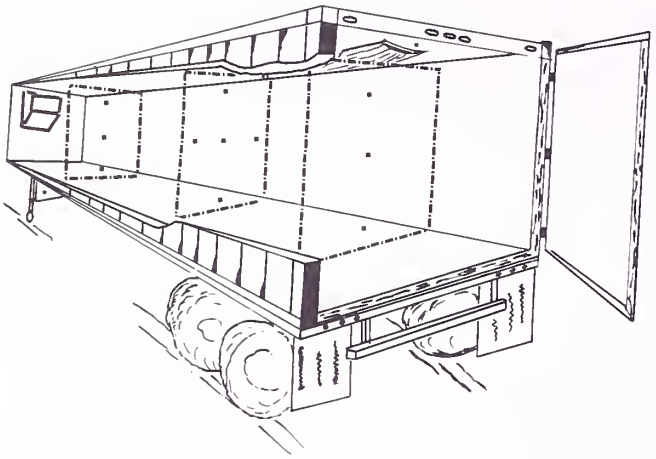

Figure 2.—Location of recording thermometers used to monitor product and air temperatures during lettuce tests. Cross sections are at ¼-length, ½-length, and ¾-length of trailer.

Figure 3.—An operator-made bulkhead that allows air to return to the refrigeration unit from under the load. Note the grooved walls on this trailer.

tional thermometer was placed under the trailer to record ambient temperatures during the transit period.

We also measured lettuce temperatures with a hand-held electric thermometer during the loading of each shipment. At destination, we measured the temperature of lettuce in each box at the ¼-length, ½-length, and ¾-length stacks, as the trailer was unloaded. At least 90 individual temperature readings were recorded at destination for lettuce in each of the 10 monitored test loads.

In addition to the 10 test shipments that we followed to eastern destinations, we obtained information on 623 refrigerated highway trailers that were preparing to load lettuce at central California shipping points. Among the features that we evaluated were the condition and type of walls and floors, whether the trailer was equipped with a front bulkhead that would allow the air in the trailer to return to the refrigeration unit without short circuiting over the top of the load (fig. 3), and whether the trucker used load bars to secure the rear of the load so it would not fall against the rear doors in transit.

Results

Temperatures of Naked-Pack Lettuce Loaded Directly on Trailer Floors

The average pulp temperature of naked lettuce placed directly on the trailer floor taken during loading at Salinas was 37.2°F (2.9°C) (table 1). The highest pulp temperature observed during loading was 42°F (5.6°C); the lowest, 33°F (0.6°C). The high, average, and low air temperatures in lettuce boxes recorded during transit for a typical shipment of naked lettuce loaded on the trailer floor are shown in figure 4. These temperatures, taken with recording ther-

Table 1.—*High, average, and low loading and arrival temperatures of lettuce shipped in 2 types of loads from Salinas, Calif., to eastern markets, summer, 1979*

Type of load	Loading temperatures			Arrival temperatures		
	High	Average	Low	High	Average	Low
	°F	°F	°F	°F	°F	°F
Naked on floor	42	37.2	33	68	45.2	35
Naked on racks	47	38.8	34	49	40.6	35

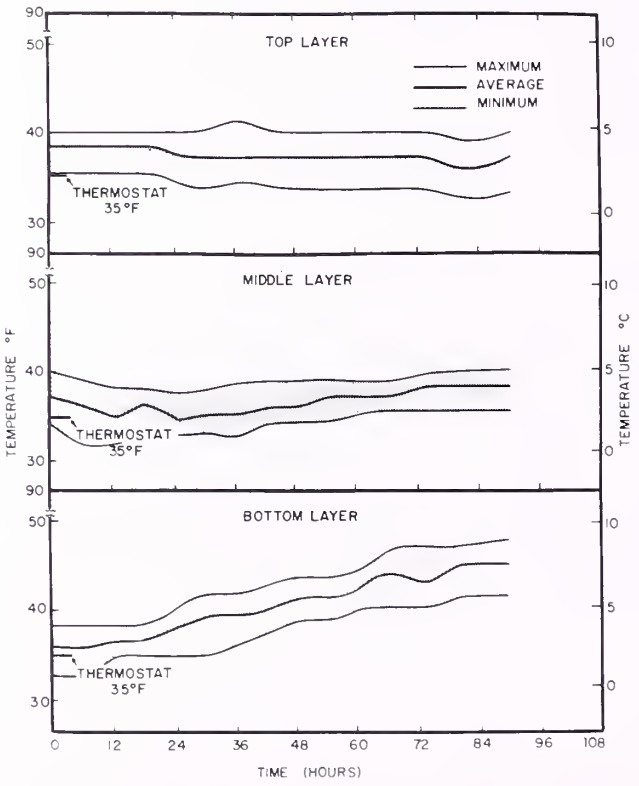

Figure 4.—High, average, and low temperatures during transit of a naked-pack lettuce load placed on the trailer floor.

mometers, do not exactly match the arrival temperatures given in table 1 because temperatures measured with recording thermometers placed in closed cartons consistently lag behind temperatures measured with hand-held electronic instruments, as previously shown by Kasmire (*3*).

During transit to eastern markets, air temperatures in lettuce boxes increased until the average pulp temperature during unloading was 45.2°F (7.4°C). The highest pulp temperature recorded was 68°F) (20.0°C); the lowest, 35°F (1.7°C).

The top layers in loads were the coolest, and the bottom layers were the warmest. The average pulp temperature on arrival was more than 10°F (5.6°C) higher in the bottom layer than it was in the top layer (table 2). Additional data given in appendix table 1 indicate that the bottom layers of lettuce are warmer than the top layers, regardless of longitudinal position in the truck trailer.

Temperatures of Naked-Pack Lettuce Loaded on Floor Racks

The average pulp temperature of naked lettuce loaded on floor racks measured during loading at Salinas was 38.8°F (2.8°C) (table 1). The high pulp temperature observed at loading was 47°F (8.3°C); the low, 34°F (1.1°C). Figure 5 depicts the high, average, and low air temperatures in lettuce boxes recorded for a typical shipment of naked lettuce loaded on racks in refrigerated trailers.

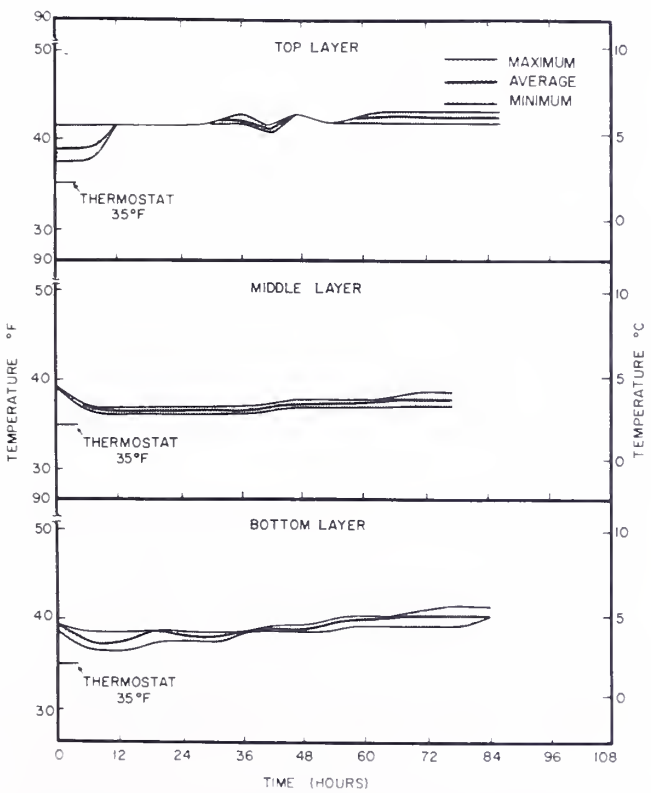

Figure 5.—High, average, and low temperatures during transit of naked-pack lettuce loaded on floor racks in a refrigerated trailer.

Temperatures increased during transit to eastern markets until the average pulp temperature at arrival was 40.6°F (4.8°C). The highest pulp temperature recorded at arrival was 49°F (9.4°C); the lowest, 35°F (1.7°C).

The top layers of this load were also the coolest and the bottom layers were the warmest (table 2); however, the bottom layers were less than 4°F (2.2°C) warmer than the top layers. The wood floor racks between the lettuce load and the trailer floor allowed refrigerated air to pass under the load, which reduced the amount of heating in the lower layers. The additional data given in appendix table 2 also indicate that heating in the lower layers is less for lettuce loaded on racks than directly on the truck trailer floor, regardless of longitudinal position in the truck trailer.

Table 2.—*Arrival temperatures of lettuce at various layers of 2 types of shipping loads from Salinas, Calif., to eastern markets, summer, 1979*

Layer	Naked lettuce loaded on the floor			Naked lettuce loaded on floor racks		
	High	Average	Low	High	Average	Low
	°F	°F	°F	°F	°F	°F
Top	48	39.7	35	46	38.8	36
2	52	41.6	35	48	39.6	36
3	54	42.9	37	48	40.6	35
4	60	43.3	38	49	40.7	36
5	60	44.5	40	49	41.1	36
6	64	46.5	41	49	41.5	36
7	68	49.9	42	47	42.3	38

Temperatures of Lettuce Adjacent to Sidewalls of Trailers

Naked lettuce loaded on the floor and also that loaded on racks were transported to eastern markets in trailers that had either flat walls or walls with recessed grooves. The recessed grooves allowed some air to circulate down between the sidewalls of the trailer and the lettuce load, much as the floor racks allowed air to circulate between the floor of the trailer and the load. On arrival, lettuce temperatures were measured in the center and on the sides of the load.

For both types of loads, the lettuce temperatures were warmer against the sidewall than along the centerline of the trailer (table 3). The differences in temperature between the sidewall boxes and centerline boxes were greatest for the lettuce loaded directly on the floor. This difference averaged less than 1°F (0.6°C) for lettuce that was loaded on floor racks, but was 3.6°F (2.0°C) for lettuce loaded directly on the floor.

The differences in temperature between loads in trailers with flat walls and those in trailers with recessed-grooved walls are even more noticeable (table 3). For naked lettuce loaded on floor racks there was essentially no difference between the centerline boxes and the boxes against the side of the grooved-wall trailer, while the sidewall boxes were

Table 3.—*Average arrival temperatures of lettuce at the sides and centers of 2 types of loads shipped in trailers with flat or grooved sidewalls from Salinas, Calif., to eastern markets, summer, 1979*

Type of load and type of trailer wall	Location in load		
	Left side	Center	Right side
	°F	°F	°F
Naked on racks:			
Flat walls	42.2	40.5	42.7
Grooved walls	37.3	38.1	38.7
Naked on floor:			
Flat walls	46.8	43.1	48.5
Grooved walls	42.6	40.8	44.1

about 2°F (1.1°C) higher than the centerline boxes in flat-wall trailers.

For naked lettuce loaded directly on the floor, the temperature differences between centerline boxes and boxes adjacent to the sidewall were 4.6°F (2.6°C) for flat-wall trailers and 2.6°F (1.4°C) for grooved-wall trailers.

Characteristics of Trailer Equipment

The types of refrigerated trailers used to transport lettuce during the 1979 season in central California are summarized in table 4. Most of the trucks had extruded-grooved floors, which allow very little air to circulate under the load and return to the refrigeration unit. A floor built in the shape of a T allows more space for air to circulate under the load, but may cost more than the extruded-grooved floor. Less than 50 percent of the trailers had completely clean floors. Any amount of dirt and trash in the floor grooves restricts air movement under the load.

Nearly three-quarters of the trailers had flat sidewalls, which prevent air from circulating between the wall and the product stacked against the wall. Walls with recessed grooves or protruding ribs allow refrigerated air to circulate over the surface of the sidewalls, dissipating heat that is conducted through the walls on hot summer days. Trailers with ribbed walls are more likely to be damaged than trailers with flat walls during loading and unloading, and they may have less available space than flat-walled trailers.

Nearly two-thirds of the trailers had some kind of front bulkhead to allow air to return from the floor to the refrigeration unit. Most of them were operator made (fig. 3); however, just placing pallets on end at the front of the trailer before loading provides a passage for the air to return to the unit.

Use of load-restraining bars at the rear of the loads holds the last boxes in place so they will not fall against the back doors. When these boxes fall against the doors, air cannot circulate down to the floor, and the boxes are a hazard to persons opening the doors at destination. About 30 percent of the trucks loaded did not have these restraining devices.

Table 4.—*Characteristics of refrigerated trailers observed during loading at Salinas, Calif., summer, 1979*

Trailer feature	Percentage of trailers with indicated feature
Type of floor:	
Extruded grooved	98.1
"T" type	1.9
Type of sidewall:	
Flat	73.8
Recessed grooves or protruding ribs	26.2
Type of bulkhead:	
None	35.1
Manufactured	7.8
Operated devised	57.1
Load bars used:	
None	32.8
1	20.6
2	35.0
3 or more	11.6
Air delivery chute:	
Single, wide canvas	86.9
None	6.1
Trailer precooled before loading:	
Yes	7.5
No	92.5
Inside trailer width:	
Less than 88 inches (223.5 cm)	3.9
88-90 inches (223.5—228.6 cm)	87.5
More than 90 inches (228.6 cm)	8.6
Inside trailer height:	
Less than 96 inches (243.8 cm)	10.8
96-102 inches (243.8—259.1 cm)	81.6
More than 102 inches (259.1 cm)	7.6
Rear door opening height:	
Less than 96 inches (243.8 cm)	46.4
96-102 inches (243.8-259.1 cm)	49.8
More than 102 inches (259.1 cm)	3.8

Nearly all trailers were equipped with a canvas air-delivery chute. About 6 percent did not have any air-delivery chute.

Most of the trailers were not precooled to the desired lettuce transit temperature before loading commenced. The USDA has recommended that transport vehicles be cooled before loading until the inside surfaces of the trailer are at the desired loading temperature (*1*).

The inside dimensions of trailers that were available for loading were obtained because they are important for determining loading patterns. An increasing amount of lettuce is being unitized, so inside width, height, and door-height opening are important. Inside widths of about 4 percent of the trailers were less than 88 inches (223.5 cm), 8 percent were greater than 90 inches (228.6 cm), and the rest, 87.5 percent, were from 88 to 90 inches (223.5 to 228.6 cm).

Only 10.8 percent of the trailers had an inside height of less than 96 inches (243.8 cm), but 46.4 percent had door openings of less than 96 inches (243.8 cm), which restricts the height of the unit that can be

machine loaded. Nearly one-half of the trailers had door openings that were between 96 and 102 inches (243.8 and 259.1 cm) high.

Conclusions and Recommendations

Based on the data that we obtained during the summer months of 1979, naked-pack lettuce should be loaded on racks several inches off the floor in trailers with ribbed sidewalls, if shippers and receivers expect to minimize high temperature arrivals. Naked lettuce loaded on racks had an average arrival temperature of slightly over 40°F (4.4°C) and averaged 4.6°F (2.6°C) cooler than naked lettuce loaded directly on trailer floors.

Although we did not specifically test the effect of **T**-type floors on lettuce temperatures, they provide more space under the load than extruded-grooved floors, and should, therefore, reduce the amount of warming that occurs in the bottom layers of a load. Less than 2 percent of the trailers observed in this study had **T**-type floors.

Lettuce loaded in trailers with recessed vertical-grooved walls arrived with sidewall temperatures that were about 2°F (1.1°C) cooler than lettuce that was loaded in trailers with flat walls; however, nearly three-fourths of the trailers observed had flat walls. Most truckers prefer flat-walled trailers because they are less easily damaged, less costly to purchase, and allow for more inside room than trailers with grooved walls.

Since the temperatures of lettuce loaded against the sidewalls of trailers were warmer than those of lettuce in the center of the load, research should be conducted to determine (1) if a load pattern that would allow air to move down the sidewall would reduce these high temperatures, and (2) if loading palletized lettuce away from the sidewalls would result in improved arrival temperatures.

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Appendix

Appendix Table 1.—*High, average, and low arrival temperatures of naked-pack California lettuce loaded on trailer floors by position in the load, summer, 1979*

Layer	¼-length			½-length			¾-length		
	High	Average	Low	High	Average	Low	High	Average	Low
	°F	°F	°F	°F	°F	°F	°F	°F	°F
Top	48	39.2	36	46	39.7	36	48	40.3	35
2	52	40.9	37	52	42.2	36	52	41.8	35
3	53	42.4	37	54	43.8	38	53	42.6	39
4	54	43.4	38	60	44.6	38	53	43.0	40
5	53	44.3	40	60	44.6	40	53	44.6	40
6	58	46.7	41	64	46.1	42	55	46.6	43
7	59	50.3	42	68	50.7	44	57	48.6	43
	60	54.2	51	58	52.2	47	55	51.0	46

Loading temperatures: High, 42°; low, 33°; average, 37.2°.
Arrival temperatures: High, 68°; low, 35°; average, 45.2°.

Appendix Table 2.—*High, average, and low arrival temperatures of naked-pack California lettuce loaded on racks, by position in load, summer, 1979*

Layer	¼-length			½-length			¾-length		
	High	Average	Low	High	Average	Low	High	Average	Low
	°F	°F	°F	°F	°F	°F	°F	°F	°F
Top	46	39.5	36	41	38.7	36	45	38.3	37
2	48	39.9	36	44	39.6	37	43	39.2	36
3	48	40.5	35	46	41.2	38	44	40.2	36
4	49	40.5	36	47	41.5	39	42	40.2	36
5	49	40.7	36	47	41.6	38	45	40.9	38
6	48	41.3	36	46	41.7	38	49	41.5	37
7	47	42.6	38	46	42.8	41	46	41.4	38

Loading temperatures: High, 47°; low, 34°; average, 38.8°.
Arrival temperatures: High, 49°; low, 35°; average, 40.6°.

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